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Asymmetric Digital Subscriber Line

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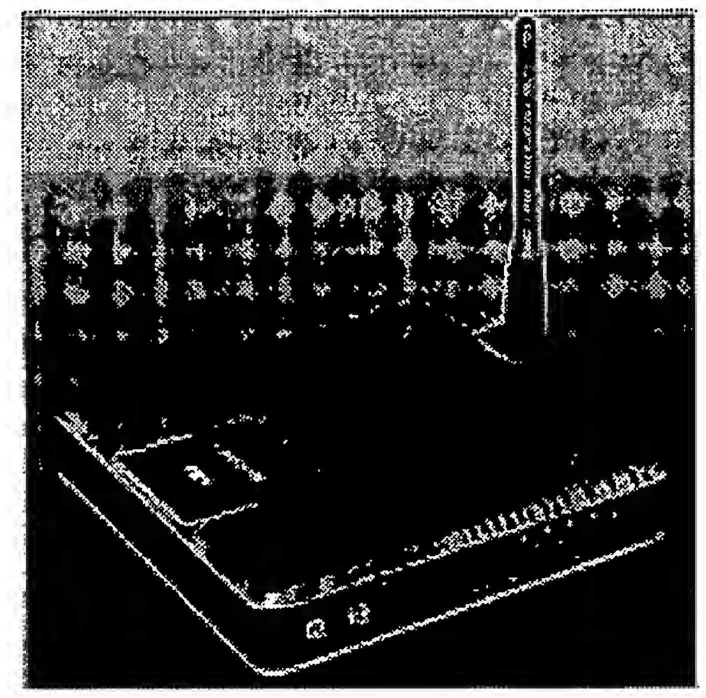

A gateway is commonly used to make an ADSL connection. The model pictured is also a wireless access point, hence the antenna.

Asymmetric Digital Subscriber Line (**ADSL**) is a form of DSL, a data communications technology that enables faster data transmission over copper telephone lines than a conventional voiceband modem can provide. It does this by utilizing frequencies that are not used by a voice telephone call. A splitter - or microfilter - allows a single telephone connection to be used for both ADSL service and voice calls at the same time. Because phone lines vary in quality and were not originally engineered with DSL in mind, it can generally only be used over short distances, typically less than 4km[1].

At the telephone exchange the line generally terminates at a DSLAM where another frequency splitter separates the voice band signal for the conventional phone network. Data carried by the ADSL is typically routed over the telephone company's data network and eventually reaches a conventional internet network. In the UK under British Telecom the data network in question is its ATM network which in turn sends it to its IP network IP Colossus.

Contents

Explanation

The distinguishing characteristic of ADSL over other forms of DSL is that the volume of data flow is greater in one direction than the other, i.e. it is asymmetric. Providers usually market ADSL as a service for consumers to connect to the Internet in a relatively passive mode: able to use the higher speed direction for the "download" from the Internet but not needing to run servers that would require high speed in the other direction.

There are both technical and marketing reasons why ADSL is in many places the most common type offered to home users. On the technical side, there is likely to be more crosstalk from other circuits at the DSLAM end (where the wires from many local loops are close to each other) than at the customer premises. Thus the upload signal is weakest at the noisiest part of the local loop, while the download signal is strongest at the noisiest part of the local loop. It therefore makes technical sense to have the DSLAM transmit at a higher bit rate than does the modem on the

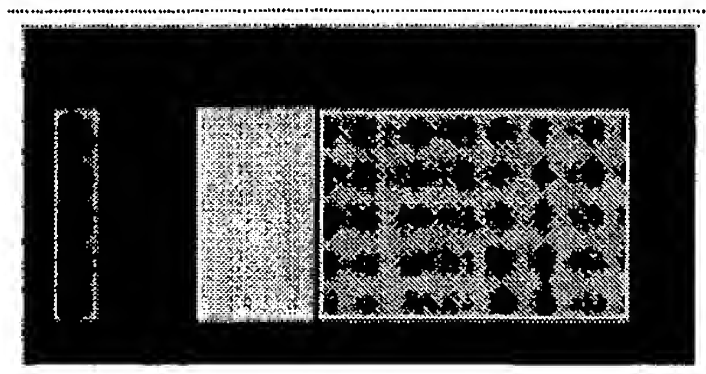
customer end. Since the typical home user in fact does prefer a higher download speed, the telephone companies chose to make a virtue out of necessity, hence ADSL. On the marketing side, limiting upload speeds limits the attractiveness of this service to business customers, often causing them to purchase higher cost Digital Signal 1 services instead. In this fashion, it segments the digital communications market between business and home users.

How ADSL works

On the wire

Currently, most ADSL communication is full duplex. Full duplex ADSL communication is usually achieved on a wire pair by either frequency division duplex (FDD), echo canceling duplex (ECD), or time division duplexing (TDD). FDM uses two separate frequency bands, referred to as the upstream and downstream bands. The upstream band is used for communication from the end user to the telephone central office. The downstream band is used for communicating from the central office to the end user.

With standard ADSL (annex A), the band from 25.875 kHz to 138 kHz is used for upstream communication, while 138 kHz – 1104 kHz is used for downstream communication. Each of these is further divided into smaller frequency channels of 4.3125 kHz. During initial training, the ADSL modem tests which of the available channels have an acceptable signal-to-noise ratio. The distance from the telephone exchange, noise on the copper wire, or interference from AM radio stations may introduce errors on some frequencies. By keeping the channels small, a high error rate on one frequency thus need not render the line unusable: the channel will not be used, merely resulting in reduced throughput on an otherwise functional ADSL connection.



Frequency plan for ADSL. The red area is the frequency range used by normal voice telephony (PSTN), the green (upstream) and blue (downstream) areas are used for ADSL.

Vendors may support usage of higher frequencies as a proprietary extension to the standard. However, this requires matching vendor-supplied equipment on both ends of the line, and will likely result in crosstalk problems that affect other lines in the same bundle.

There is a direct relationship between the number of channels available and the throughput capacity of the ADSL connection. The exact data capacity per channel depends on the modulation method used.

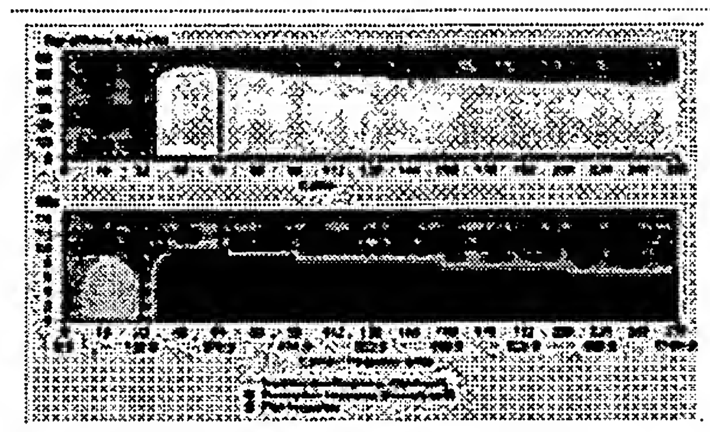
Modulation

ADSL initially existed in two flavours (similar to VDSL), namely CAP and DMT. CAP was the *de facto* standard for ADSL deployments up until 1996, deployed in 90 percent of ADSL installs at the time. However, DMT was chosen for the first ITU-T ADSL standards, G.992.1 and G.992.2 (also called *G.dmt* and *G.lite* respectively). Therefore all modern installations of ADSL are based on the DMT modulation scheme.

ADSL standards

Standard name	Common name	Downstream rate	Upstream rate
ANSI T1.413-1998 Issue 2	ADSL	8 Mbit/s	1.0 Mbit/s
ITU G.992.1	ADSL (G.DMT)	12 Mbit/s	1.3 Mbit/s
ITU G.992.1 Annex A	ADSL over POTS	12 Mbit/s	1.3 MBit/s
ITU G.992.1 Annex B	ADSL over ISDN (IDSL)	12 Mbit/s	1.8 MBit/s

ITU G.992.2	ADSL Lite (G.Lite)	1.5 Mbit/s	0.5 Mbit/s
ITU G.992.3/4	ADSL2	12 Mbit/s	1.0 Mbit/s
ITU G.992.3 Annex J	ADSL2	12 Mbit/s	1.0 Mbit/s
ITU G.992.3 Annex L[2]	RE-ADSL2	5 Mbit/s	0.8 Mbit/s
ITU G.992.5	ADSL2+	24 Mbit/s	1.0 Mbit/s
ITU G.992.5 Annex M	ADSL2+M	24 Mbit/s	3.5 Mbit/s



Frequencies spectrum of a Fritz modem on an ADSL Belgian line.

Annexes J and M shift the upstream/downstream frequency split up to 276 kHz (from 138 kHz used in the commonly deployed annex A) in order to boost upstream rates. Additionally, the "all-digital-loop" variants of ADSL2 and ADSL2+ (annexes I and J) support an extra 256 kbit/s of upstream if the bandwidth normally used for POTS voice calls is allocated for ADSL usage.

While the ADSL access utilizes the 1.1 MHz band, ADSL2+ utilizes the 2.2 MHz band.

The downstream and upstream rates displayed are theoretical maxima. Note also that because Digital subscriber line access multiplexers and ADSL modems may have been implemented based on differing or incomplete standards some manufacturers may advertise different speeds. For example, Ericsson has several devices that support non-standard upstream speeds of up to 2 Mbit/s in ADSL2 and ADSL2+.

Installation issues

Due to the way it uses the frequency spectrum, ADSL deployment presents some issues. It is necessary to install appropriate frequency filters at the customer's premises, to avoid interferences with the voice service, while at the same time taking care to keep a clean signal level for the ADSL connection.

In the early days of DSL, installation required a technician to visit the premises. A splitter was installed near the demarcation point, from which a dedicated data line was installed. This way, the DSL signal is separated earlier and is not attenuated inside the customer premises. However, this procedure is costly, and also caused problems with customers complaining about having to wait for the technician to perform the installation. As a result, many DSL vendors started offering a self-install option, in which they ship equipment and instructions to the customer. Instead of separating the DSL signal at the demarcation point, the opposite is done: the DSL signal is "filtered off" at each phone outlet by use of a low pass filter, also known as microfilter. This method does not require any rewiring inside the customer premises.

A side effect of the move to the self-install model is that the DSL signal can be degraded, especially if more than 5 voiceband devices are connected to the line. The DSL signal is now present on all telephone wiring in the building, causing attenuation and echo. A way to circumvent this is to go back to the original model, and install one filter upstream from all telephone jacks in the building, except for the jack to which the DSL modem will be connected. Since this requires wiring changes by the customer and may not work on some household telephone wiring, it is rarely done. It is usually much easier to install filters at each telephone jack that is in use.

See also

- British telephone sockets

- Broadband Internet access
- Digital Subscriber Line for further details and other varieties
- Digital subscriber line access multiplexer
- ADSL loop extender can be used to expand the reach and rate of ADSL services.
- Filter and splitter.
- Symmetric Digital Subscriber Line
- Rate-Adaptive Digital Subscriber Line (RADSL)
- Flat rate
- Attenuation distortion
- ADSL max
- List of device bandwidths

Notes

1. ^ Data and Computer Communications, William Stallings, ISBN-10: 0132433109, ISBN-13: 978-0132433105
2. ^ ADSL2 Annex L is also known as RE-ADSL2, where 'RE' stands for 'Reach Extended.' With this ADSL standard, the power of the lower frequencies used for transmitting data is boosted up to increase the reach of this signal up to 7 kilometers (23,000 ft). The upper frequency limit for RE-ADSL2 is reduced to 552 kHz to keep the total power roughly the same as annex A. Since RE-ADSL2 is intended for use on long loops there isn't much (any) usable bandwidth above 552 kHz anyway. Although this standard has been ratified by the ITU, not all local loop network maintainers allow this protocol to be used on their network, lest the extra power on the lower frequencies cause problems for existing services due to crosstalk.

References

External links

- ADSL Theory (http://whirlpool.net.au/wiki/?tag=ADSL_Theory) — Good information about the background & workings of ADSL, and the factors involved in achieving a good sync between your modem and the DSLAM.
- Free calculator used by telephone companies to compute bandwidth vs. distance (http://www.strowger.com/Widearea-ADSL-Loop-Extender/37-Loop-Extender-for-ADSL/61-adsl2-bandwidth-e
- The UNH-IOL DSL Knowledge Base (advanced tutorials) (http://www.iol.unh.edu/training/dsl/)
- ADSL, ADSL2 and ADSL2+ Speeds and Reach Compared (http://www.internode.on.net/adsl2/graph/)
- ADSL Research Report (http://www.esatclear.ie/~aodhoh/adsl/report.html)
- ADSL Tutorial (http://www2.rad.com/networks/2005/adsl/main.htm)
- DSL How-To (http://www.tldp.org/HOWTO/DSL-HOWTO/) Complete guide from scratch; how to install cabling & service, and configure a linux-based machine as an advanced/sophisticated router.
- Various ADSL Technical Information (http://www.systemtek.co.uk/TechDocs/Telecom_General/ADSL_Tech_docs.htm)
- History of DSL (http://www.thehistoryof.net/history-of-dsl.html)

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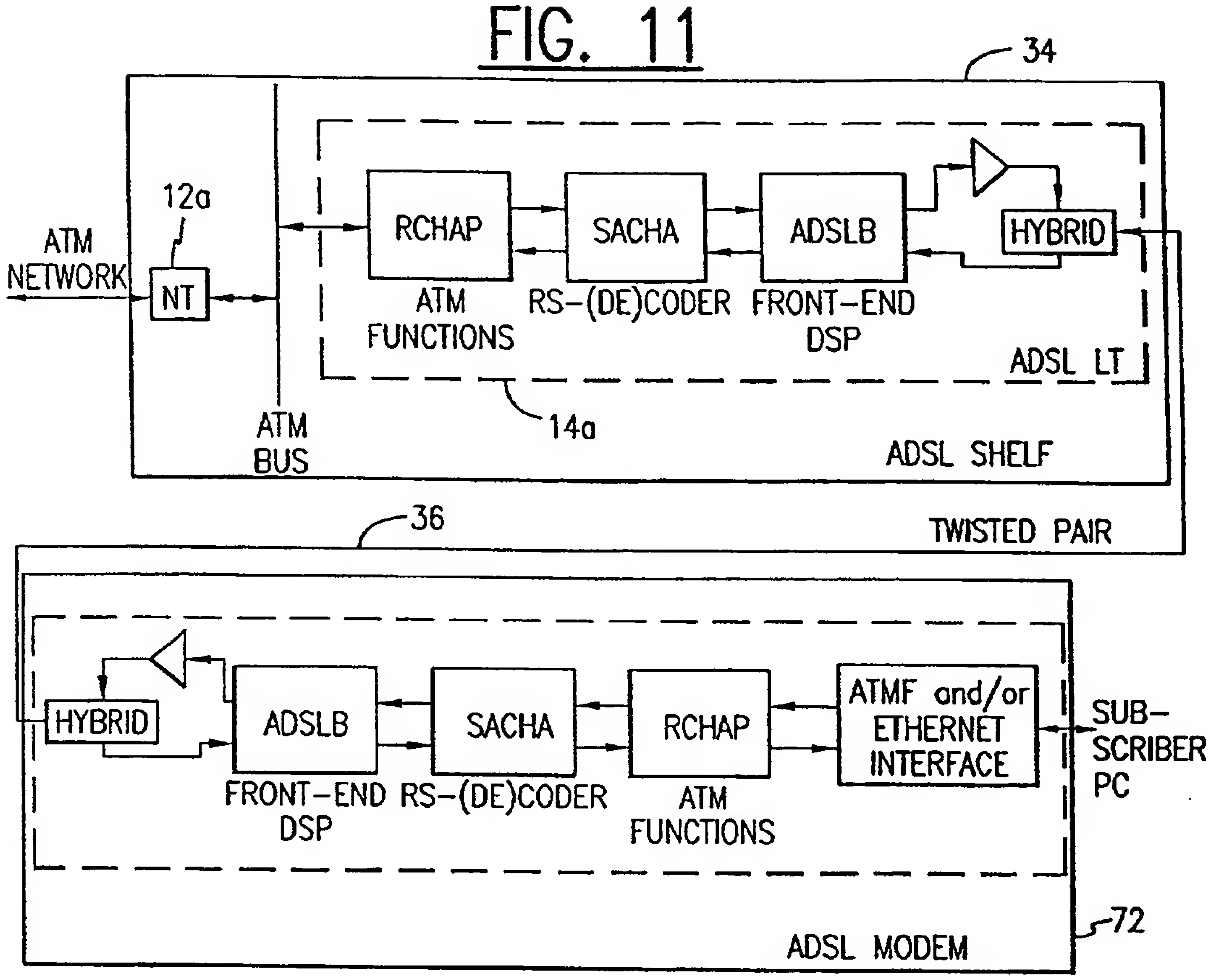
FIG. 11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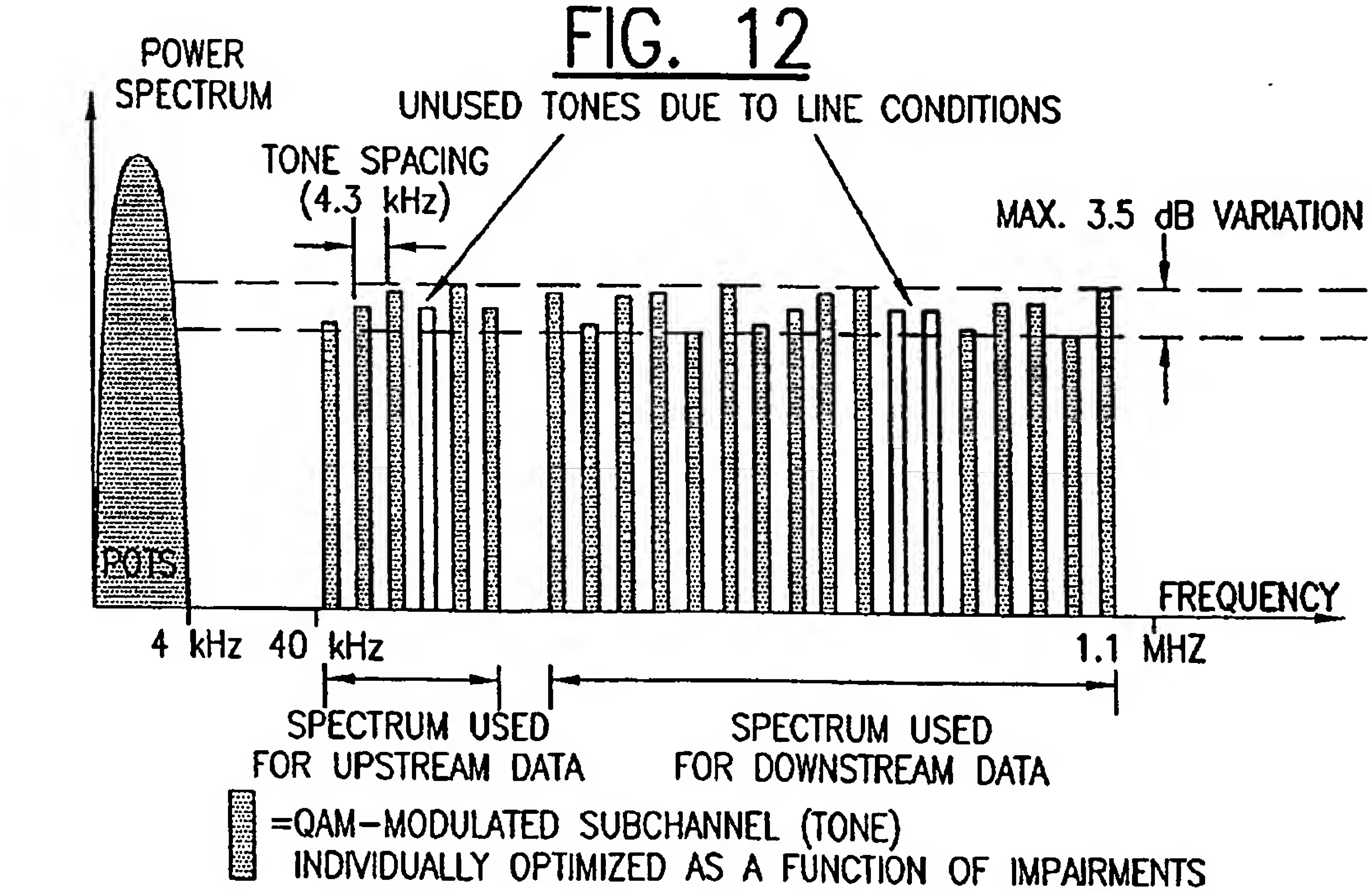
ATM NETWORK
12a
NT
ATM BUS
RCHAP
ATM FUNCTIONS
SACHA
RS-(DE)CODER
ADSLB
FRONT-END DSP
HYBRID
ADSL LT
14a
ADSL SHELF
36
TWISTED PAIR
HYBRID
ADSLB
FRONT-END DSP
SACHA
RS-(DE)CODER
RCHAP
ATM FUNCTIONS
ATMF and/or ETHERNET INTERFACE
SUB-SCRIBER PC
72
ADSL MODEM

FIG. 12


POWER SPECTRUM
UNUSED TONES DUE TO LINE CONDITIONS
TONE SPACING (4.3 kHz)
MAX. 3.5 dB VARIATION
POTS
FREQUENCY
4 kHz
40 kHz
1.1 MHZ
SPECTRUM USED FOR UPSTREAM DATA
SPECTRUM USED FOR DOWNSTREAM DATA
=QAM-MODULATED SUBCHANNEL (TONE) INDIVIDUALLY OPTIMIZED AS A FUNCTION OF IMPAIRMENTS